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# EDITOR'S COMMENTS

Presenting the 2020 fall issue of the *Journal of the Washington Academy of Sciences*.

There are four papers in this issue plus one interesting Science Bite. First up is a paper on an impact crater (made by meteorites striking the Earth). To follow are two fun studies of math questions. Finally there is a student paper on various examples for rejecting a peer reviewed paper.

At the end are the bios of the 2020 WAS awardees and two speeches: one by the outgoing WAS President; and one by the incoming WAS President. Our 2020 annual meeting and awards banquet was a virtual event.

Please consider submitting short (typically one page) papers on an interesting tidbit in science. There are a lot of interesting tidbits out there. Every science field has them. They sit in your brain ready to share. We all want to learn about things in fields other than our own. So pile them up and send them in.

The Journal is the official organ of the Academy. Please consider sending in technical papers, review studies, announcements, SciBites, and book reviews. Send manuscripts to wasjournal@washacadsci.org. If you are interested in being a reviewer for the *Journal*, please send your name, email address, and specialty to the same address. Each manuscript is peer reviewed, and there are no page charges. As you can tell from this issue we cover a wide range of the sciences.

I encourage people to write letters to the editor. Please send by email (wasjournal@washacadsci.org) comments on papers, suggestions for articles, and ideas for what you would like to see in the Journal. I also encourage student papers and will help the student learn about writing a scientific paper.

I hope everyone remains safe and healthy in this time of pandemic.

Sethanne Howard


**Journal of the Washington Academy of Sciences**

**Editor** Sethanne Howard showard@washacadsci.org

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5. Use Times New Roman, font size 12.
6. Include two to three sentence bios of the authors.
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# PROPOSED MIAMI IMPACT CRATER IDENTIFIED AS A SOLUTIONAL DOLINE OF OOLICTIC LIMESTONE

Antonio Paris, Ryan Robertson, & Skye Schwartz

Planetary Sciences, Inc.

## ABSTRACT

This investigation addresses the discovery of a proposed impact crater located off the coast of Miami, FL under the North Atlantic Ocean. A preliminary analysis of bathymetry data obtained from the National Oceanic and Atmospheric Administration (NOAA) implied a morphology consistent with a complex crater produced by a hypervelocity impact event of extraterrestrial origin. The proposed impact crater's features include a central peak, concentric rings, and an ejecta field to the northwest. Analysis of geological data from the US Geological Survey (USGS) places the strata overlying the proposed impact site as Miami Limestone (Pleistocene), accumulated during Marine Isotope Stage 5e, thereby placing the maximum age of the proposed impact crater at ~80 ka to ~130 ka. Three other competing hypotheses for the formation of the structure, namely a controlled maritime explosion, radial lava flow from volcano, or a depressed bioherm, doline, or karst (i.e., solutional depression) were explored throughout the investigation. To confirm the proposed structure as an impact crater, an *in-situ* underwater expedition was organized by Planetary Sciences, Inc. specifically to ascertain whether planar formations, shatter cones, and shock metamorphic and/or other meteoritic properties were present. After analyzing the geological samples collected at the proposed impact crater, examining the morphology of analogous geologic structures, and evaluating competing hypotheses, we conclude that the structure is a solutional doline formed by the uneven dissolution of the Miami Limestone, and, accordingly, do not recommend that the structure be indexed in the Earth Impact Database.

## INTRODUCTION

**THIS INVESTIGATION FOCUSES ON AN IMPACT CRATER** initially proposed by Cory Boehne in 2012. The impact crater is located 8 m under the North Atlantic Ocean at 25° 44' 59.31" N and 80° 7' 21.78" W. It is 1.20 km southeast of the entrance of Government Cut—a manmade shipping channel between Miami Beach and Fisher Island, FL (Figure 1). Although an initial inquiry was completed by Charles O'Dale in 2012,[1] the identification of the

structure remained unresolved and, as a result, it was not indexed in the official Earth Impact Database.[2]

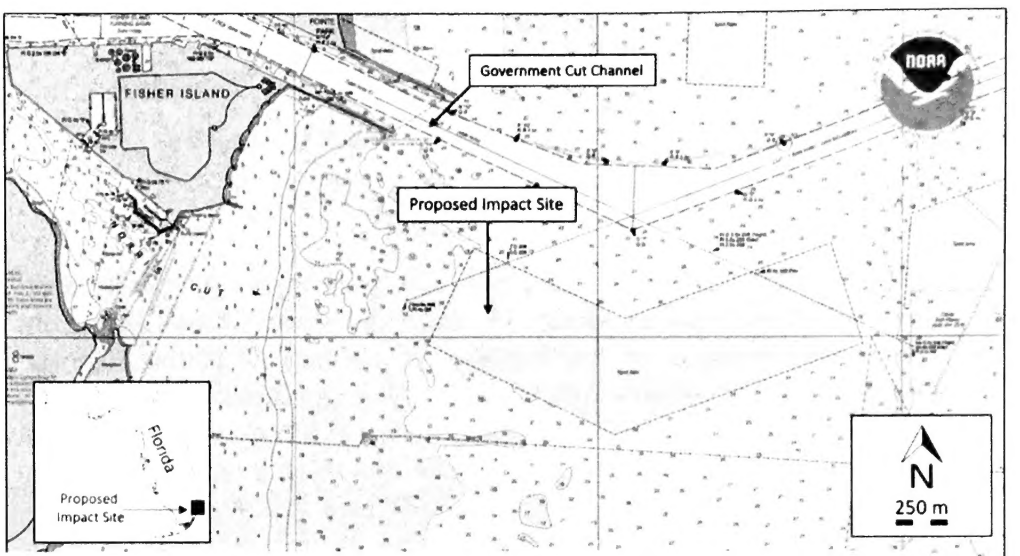


Figure 1: Location of the proposed impact crater (Source: NOAA Chart 11468)

## DATA COLLECTION

The geological data used throughout this investigation was obtained from the USGS, ArcGIS and the Association of American State Geologists (AASG).[3] Indices checks in the National Geologic Map Database (NGMDB) provided supplementary data, such as a remote sensing inventory of the proposed impact site and scholarly sources of information focused on the geologic history of southern Florida. The geologic maps and data contributed to the NGMDB have been standardized in accordance with the Geologic Mapping Act of 1992, section 31f(b), and they are widely accepted standards.

The bathymetry data used to analyze the proposed impact site was available through the National Oceanic and Atmospheric Administration (NOAA), which collects and archives multibeam and hydrographic lidar data from the earliest commercial installations. Indices checks for metadata through the NOAA's Bathymetric Data Viewer (BDV) provided a Shallow Water Multibeam Hydrographic and Side Scan Sonar Survey (Registry No. H11898) of the proposed impact site.[4] The purpose of the survey was to provide the NOAA with modern, accurate hydrographic survey data to update the nautical charts of the North Atlantic Ocean east of Key Biscayne, FL.[5] Two hundred percent side scan sonar (SSS) coverage, along with concurrent shallow water multibeam echo sounder (SWMB) coverage were

acquired with set line spacing to water depths of 20 m or shallower.[6] According to the NOAA, all equipment was installed, calibrated, and operated in accordance with the requirements set forth in its Data Acquisition and Processing Reports procedures.

To complement this investigation, an underwater expedition comprised of a SCUBA diving team was conducted *in situ*. The dive plan involved taking measurements of the prominent features of the proposed impact crater (e.g., the central peak, concentric rings, and the ejecta field), underwater photography, and the collection of geological samples for planar formation, shatter cone, and shock metamorphic analysis. These features are uniquely characteristic of the intense shock of a large meteorite impact. Volcanic explosions do not generate such shocks and these features. Aerial imagery, moreover, was acquired through the use of a crewless aerial vehicle (UAV) operated over the proposed impact site. The UAV offered a powerful camera on a 3-axis stabilized gimbal that recorded video at 4k resolution up to 60 frames per second and featured real-glass optics that captured aerial imagery at 12 megapixels from an altitude of up to 800 m and a range of up to 7 km.[7]

## GEOLOGY OF THE IMPACT SITE

Geologically, the overlying strata at the impact site is Miami Limestone (formally known as Miami Oölite), and it covers a large portion of the southern tip of Florida, at or near the surface, along the Atlantic Coastal Ridge (Figure 2).[8] The formation was deposited during the Sangamonian interglacial and Wisconsin glacial stages, when the proposed impact site was under a shallow sea, as a narrow band of oolitic carbonate in a north-south trending barrier bar system along the eastern portion of present day Miami-Dade and Broward counties.[9] Falling sea levels eventually exposed the formation to air and rain, and rainwater percolating through the deposits replaced aragonite with calcite (CaCO3) and formed an indurated rock.[10] Presently, the Miami Limestone consists of two separate units—the oölitic facies (upper unit) and the bryozoan facies (lower unit).[11] The oölitic facies consists of white to orangish gray, poorly to moderately indurated, sandy limestone (grainstone) with scattered concentrations of fossils. The bryozoan facies consist of white to orangish gray, poorly to well indurated, sandy, fossiliferous limestone (grainstone and packstone).[12] The underlying strata is Fort Thompson Formation (Pleistocene) and is

comprised of alternating freshwater and marine marls and limestones.[13] The Fort Thompson formation in the Miami area attains a maximum thickness of 25 m and constitutes the major part of the Biscayne aquifer.[14]

The Sangamonian Stage, which was the last interglacial period, is equivalent to Marine Isotope Stage 5e (MIS 5e), therefore placing the maximum age of the proposed impact crater at ~80 ka to ~130 ka.[15] Marine isotope stages are interchanging palaeotemperature maxima and minima, inferred from oxygen isotope data reflecting changes in the planet's temperature derived from data obtained through deep sea core samples.[16] In 1965, moreover, researchers used uranium-series dating and confirmed the age of Miami Limestone at ~130 ka.[17]

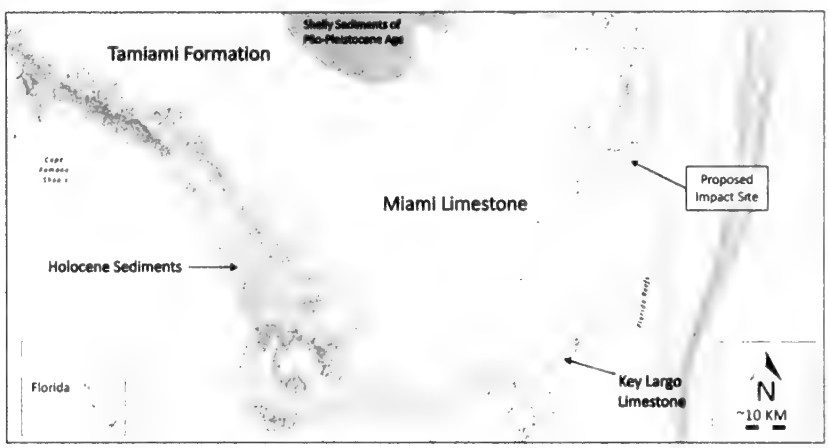


Figure 2: Geological map of South Florida (Source: ArcGIS, USGS, and Planetary Sciences, Inc.)

## AREA OF INVESTIGATION BATHYMETRY

An examination of NOAA bathymetry data (Report H11898) revealed an underwater structure illustrating morphology consistent with an impact crater produced by a hypervelocity event of extraterrestrial origin (Figure 3). The proposed impact crater has a diameter of ~650 m, has a circumference of ~2.04 km, and occupies a surface area of ~0.33 $km^2$. The prominent features, which appear more consistent with a complex crater, include a central peak and at least six outward-radiating curved ridges. The debris field ~350 m to the northwest, according to earlier research, is a proposed ejecta field associated with the impact hypothesis.[1]

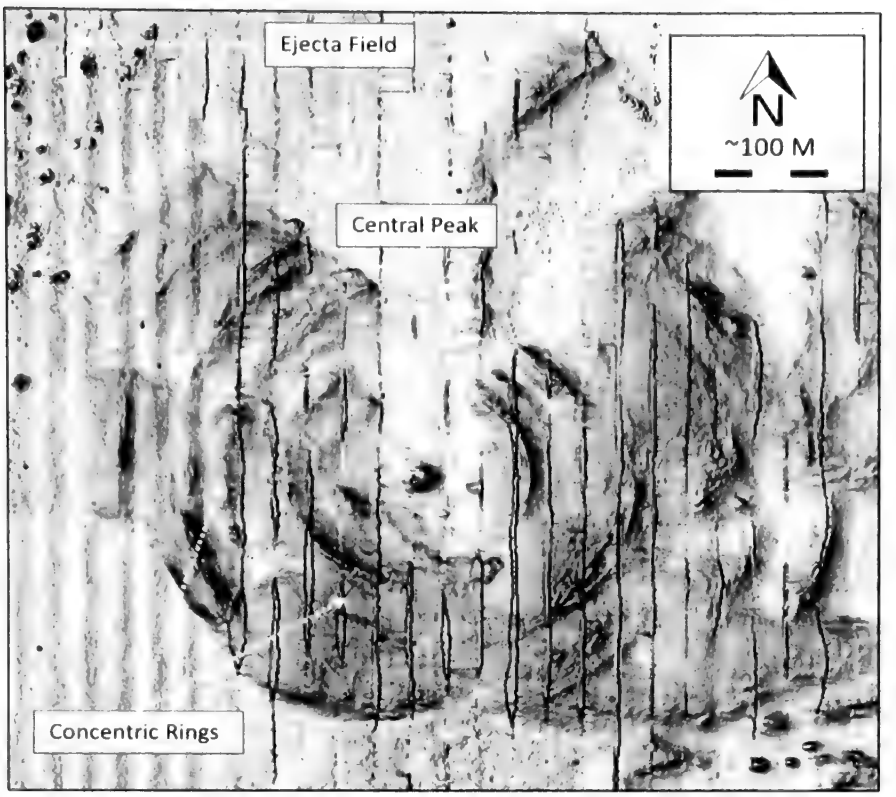


Figure 3: Bathymetry data of proposed impact site (Source: NOAA)

## IN-SITU UNDERWATER EXPEDITION

On 27 June 2020 a team of SCUBA divers surveyed the proposed impact crater. The purpose of the underwater survey was to investigate, photograph, and collect geological samples at 30 locations spread throughout the structure, which included the central peak, the northeast, southwest, northwest rings, and the proposed ejecta field (Figure 4). The underwater surveys were specifically planned for high tide at or near solar noon. Conducting the survey at or near solar noon (when the Sun is directly overhead) allowed the surface area of the proposed impact site to be lit up by the sun as much as possible.

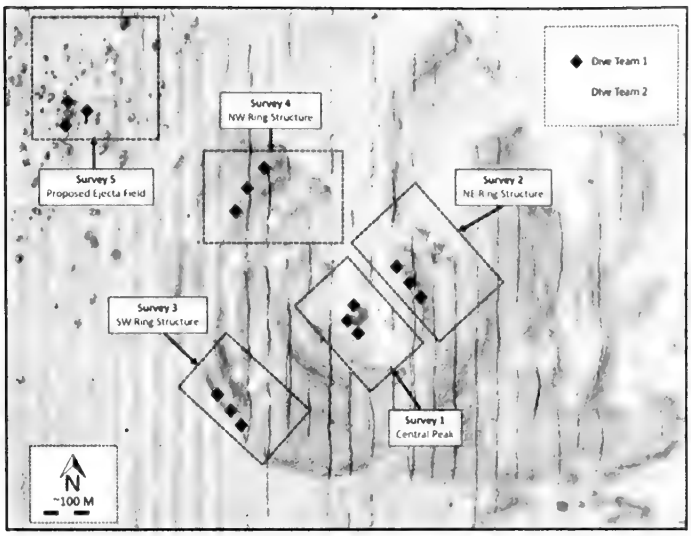


Figure 4: Underwater survey and dive plan (prepared by Planetary Sciences, Inc.)

Through the use of a computerized depth gauge, the dive team logged the proposed central peak at a depth of 8.2 m, the northeast ring at 5.79 m, the southwest ring at 6 m, and the northwest ring at 5.65 m. The recorded depths, therefore, imply that the underwater structure is a bowl-shaped depression. Furthermore, to establish whether planar formations, shatter cones, and shock metamorphic and/or other meteoritic properties were present, the dive team collected a total of 30 geological samples for analysis (Figure 5).

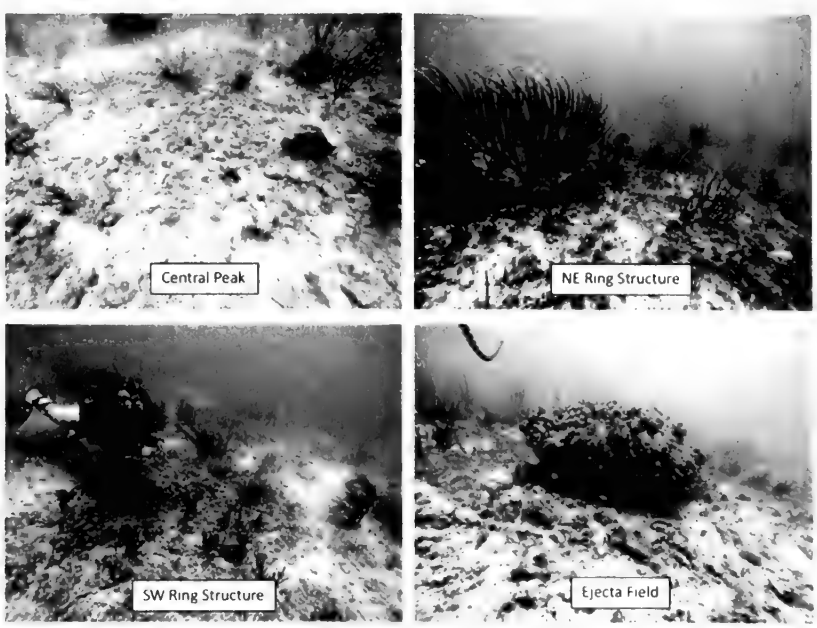


Figure 5: Underwater survey of central peak, NE and SW ring structure, and ejecta field

## ANALYSIS & INTERPRETATION

This investigation considered all possibilities for the formation of the proposed impact crater. The four competing hypotheses that could explain how the structure was formed included a controlled maritime explosion, radial lava flow from a volcano, a hypervelocity impact event of extraterrestrial origin, or a bioherm, doline, or karst formation. After investigating and analyzing all competing hypotheses, we interpret the proposed impact crater as solutional doline originating from the overlying Miami Limestone.

### Hypothesis 1: Controlled Maritime Explosion

Although various simulations of wave and debris associated with underwater explosions provided a strong argument to discredit an impact hypothesis, a central peak is not characteristic of a controlled underwater explosion.[18] Additionally, indices checks of NOAA, US Army Corps of Engineers (Jacksonville District), and US Coast Guard records returned no information regarding a controlled maritime explosion in the vicinity of 25° 44' 55.95" N and 80° 07' 12.95" W. Moreover, an examination of local historical archives dating back to at least 1903, when the dredging of Government Cut commenced, likewise rule out a controlled maritime explosion as the source for the formation of the proposed impact structure.

### Hypothesis 2: Radial Lava Flow

The USGS National Map and Volcano Hazards Program confirmed there are no known active, inactive, or ancient volcanos in the vicinity of 25° 44' 55.95" N and 80° 07' 12.95" W.[19] The Miami Limestone and Fort Thompson Formation are young geological formations and entirely non-volcanic. The geology to support a young volcano in the area, consequently, is not there. While it is probable that igneous rocks formed during the early phases of geological activity in the past (e.g., Precambrian) they are deeply buried under kilometers of sediment.[20]

### Hypothesis 3: Impact Event

There is no physical evidence to support the assertion that the proposed impact crater is the result of an impact event of extraterrestrial origin (i.e., a meteor). This confirmation is based on data gathered and analyzed during our investigation, such as the geomorphology of impact cratering on terrestrial bodies, the history of water at the impact site during the Sangamonian Stage, archival data from NASA, NOAA, and USGS, and physical evidence surveyed, recovered, and analyzed from the proposed impact site.

The formation of complex craters differs from bowl-shaped craters. Complex craters have uplifted centers, such as the proposed impact crater, but they

also develop shallow floors with terraced walls. The diameters of complex craters where central peaks form, moreover, typically form in craters greater than ~3-5 km in diameter or larger.[21] Furthermore, complex-crater morphology on terrestrial planets appears to follow a consistent sequence with increasing size: small complex craters with a central peak; intermediate-sized peak ring craters, in which the central peak is replaced by a ring of peaks; and the largest craters, which encompass multiple concentric rings, known as multi-ringed basins.[22] This sequence of features is a sequence of increasing size of the crater, that of the meteorite and speed of impact (Figure 6, B-E). Geologically, therefore, there are no known small central peak craters with multiple rings—as is the case with the proposed impact crater. Second, the Miami Limestone was deposited during the interglacial Sangamon Stage, when the impact site was ~7 m above present sea level.[23] When an small impactor hits water, such as where the Miami Crater rests, the debris (ejecta) thrown out from the impact creates a unique pattern resembling a splash or mudflow—forming what is known as a rampart crater (Figure 6, F).[24] The outer edge of the debris, which usually displays lobes, is upraised. This feature gives the name "rampart" to this type of crater. While many rampart craters exist on Mars, the Nördlinger Ries impact structure in Germany is the only confirmed rampart crater on Earth.[25]

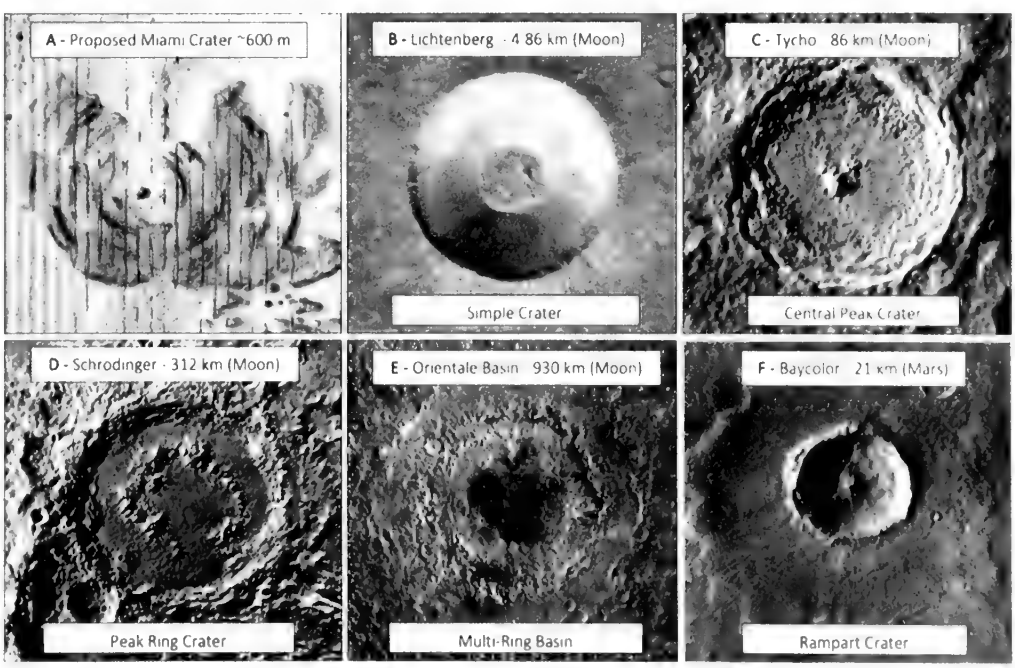


Figure 6: A comparison of the proposed impact crater (Image A) and the relation between crater sizes a complexity (Images B-F). Source: NOAA (Image A) and NASA (Images B-F)
**Not to Scale**

Furthermore, earlier researchers inferred that the "outflow of sediments running east-north-east" from the crater could be associated with the impact.[1] Bathymetric data and nautical charts from NOAA, however, indicate that the proposed impact crater rests on a designated spoilage area (dumping ground) 1.20 km south of Government Cut (Figure 7). We argue, therefore, that these sediments are not associated with an impact event, but rather material that was transported and redeposited from the dredging of Government Cut.

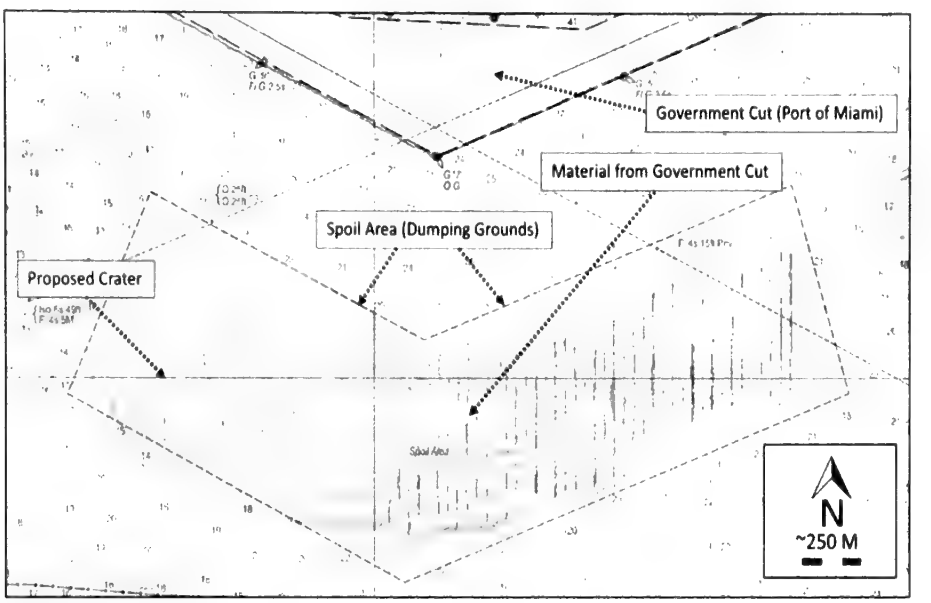


Figure 7: Spoilage area (dumping ground) for Government Cut (Source: NOAA)

**Hypothesis 4: Solutional Doline of the Underlying Limestone**

An examination of comparable basinal-shaped depressions, as well as analysis of geological samples recovered *in situ*, identified the proposed impact crater as a doline formed by the uneven dissolution of the overlaying Miami Limestone. Macroscopic inspection of the 30 geological samples collected *in situ* (Figure 8 A-D) identified the samples as white to orangish gray karst limestone composed mainly of ooids, quartz sand, calcite, macroalgae and small fossils of *Modulus m.*, *Vermicularia sp.*, *Polychaete*, and *Cerithium litteratum* (Figure 9 A and 9B).[9] Most of the aragonitic ooids have been replaced by calcite and with depth these have become increasingly embedded in a matrix of crystalline calcite.[26] During examination of the samples, we found no evidence of planar formation, shatter cone, or shock

metamorphic features in the sampling. Moreover, no meteoritic specimens were found at the proposed ejecta field.

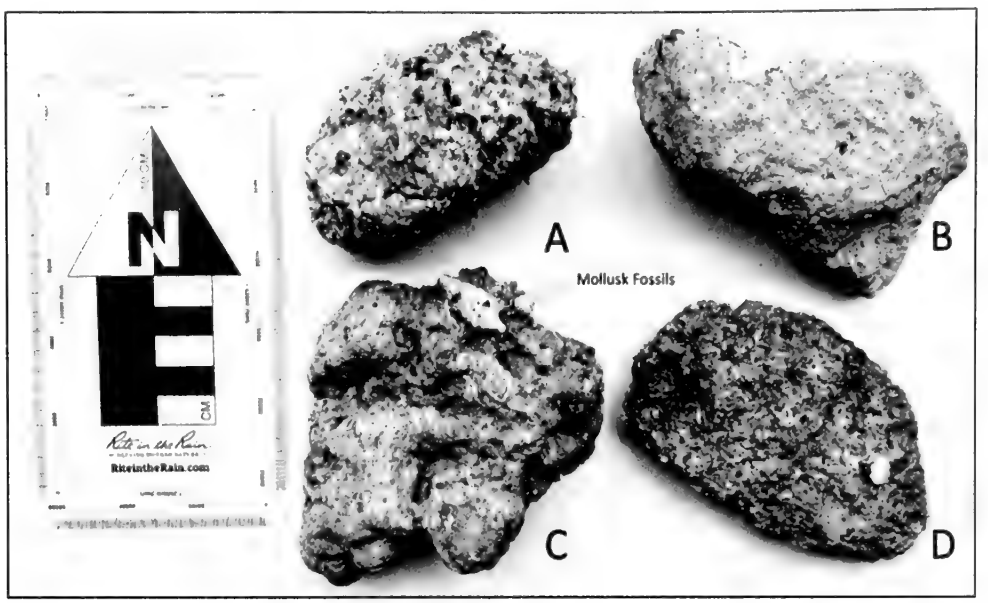


Figure 8: Samples collected at the proposed impact site.
(A) central peak, (B) NE ring, (C) NW ring, and (D) ejecta field (Source: Planetary Sciences, Inc.)

Furthermore, karstification is a long-term and continuous dissolution process of water acting over carbonate rocks such as limestone and, after time, developing geological structures such as dolines.[27] Solutional dolines are known to produce broad, saucer-like depressions, particularly in a geological setting where the overlying strata is limestone.[28] Unlike a *collapsed* sinkhole (or doline), which is formed by gravitational collapse due to an underlying cavity (*i.e.,* cave), solutional dolines can form multiple inward-dipping depressions with diameters larger than *collapsed* sinkholes or dolines. These multiple inward-dipping depressions, when observed from a position of elevation, appear as concentric outward-radiating rings analogous to complex crater morphology (Figure 10a and 10b).[29]

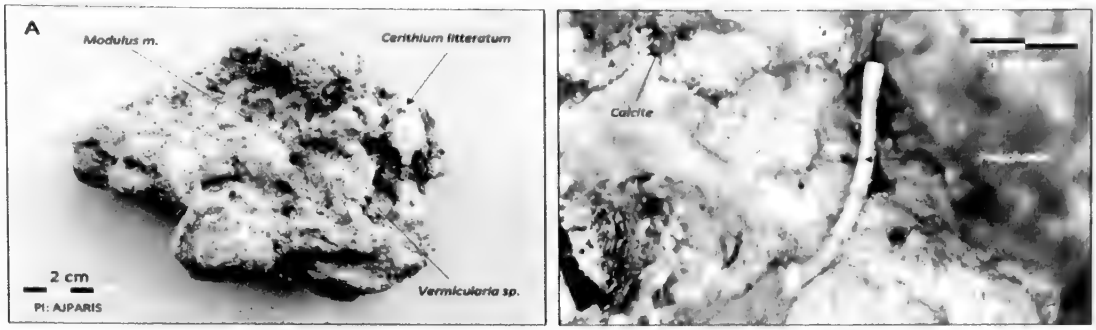


Figure 9: Macroscopic (A) and microscopic (B) images on sample collected at NW ring of

Moreover, in a geological setting where the underlying strata is primarily limestone (*i.e.,* Florida), dolines and sinkholes naturally form contiguously to each other. For illustration, further scrutiny of NOAA bathymetric data identified an additional doline ~400 m northeast of the proposed impact crater (Figure 11). This second doline exhibits morphology analogous to the proposed impact crater, which includes multiple concentric, outward-radiating rings.

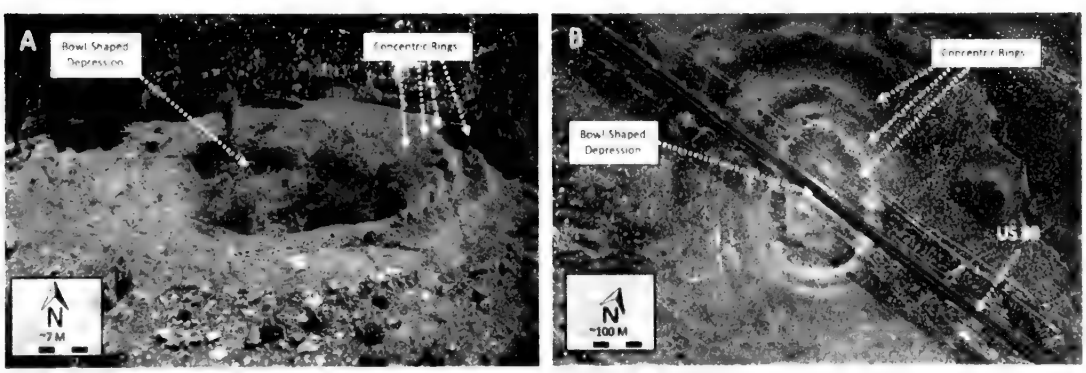


Figure 10: Analogous doline depressions with underlying limestone similar to the proposed Miami impact crater.
(A) Le Parc, France and (B) Kanab, Utah

## CONCLUSIONS

An analysis of bathymetry data, analogous topographic depressions with concentric rings with overlying limestone, and geological samples collected *in situ* has identified the proposed Miami impact crater as a solutional doline of the overlying Miami Limestone. Additionally, other competing hypotheses for the formation of the structure, such as a controlled maritime explosion or radial lava flow from volcano, were also ruled out during our investigation. Accordingly, we do not recommend that the structure be indexed in the Earth Impact Database. Furthermore, we advise

Google to update its maps and remove the current designation—*The Miami Meteorite Crater.*

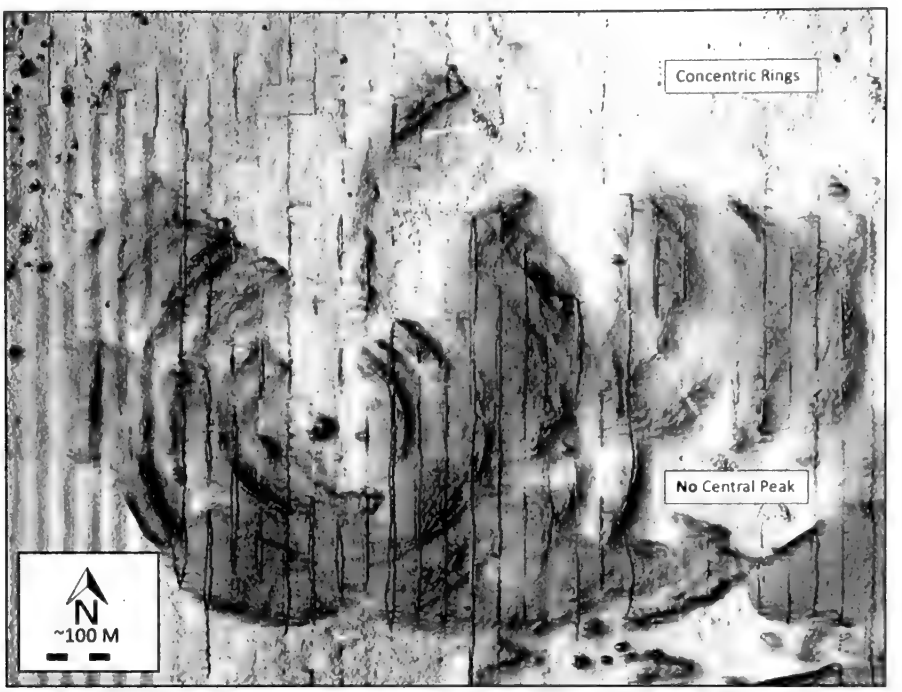


Figure 11: Similar doline with concentric rings northeast of proposed impact crater (Source: NOAA)

**BIO**

**Antonio Paris**, the Principal Investigator (PI) for this study, is the Chief Scientist at Planetary Sciences, Inc., a former Assistant Professor of Astronomy and Astrophysics at St. Petersburg College, FL, and a graduate of the NASA Mars Education Program at the Mars Space Flight Center, Arizona State University. He is the author of *Mars: Your Personal 3D Journey to the Red Planet.* His latest peer-reviewed publication is "Prospective Lava Tubes at Hellas Planitia"—an investigation into leveraging lava tubes on Mars to provide crewed missions protection from cosmic radiation. Prof. Paris is a professional member of the Washington Academy of Sciences, a member of the American Astronomical Society, and a trained SCUBA Instructor and Divemaster with the Professional Association of Divers International.

## FIELD RESEARCH CONTRIBUTERS

Ryan Robertson is the Manager of Commercial Space at Space Florida. Working in conjunction with NASA's Kennedy Space Center and the US Air Force, Ryan manages a variety of facilities spanning the State of Florida for aerospace companies to research, develop, and launch business ventures. He is currently a graduate student at American Public University studying planetary science, is a certified SCUBA diver, and has previously assisted Planetary Sciences, Inc. with research focused on Solar System bodies.

Skye Schwartz is currently an undergraduate student studying Biology at Arizona State University and the Operations Manager/Educator at Space Trek. Accepted into the NASA Solar System Ambassador program back in 2016, Skye has hosted events at schools, conferences, and NASA centers around the United States.

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# Are 2018, 2019, and 2020 Congruent?

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## Abstract

*Congruent* numbers are defined and some background information reported. We then investigate whether 2018, 2019, and 2020 are congruent.

## Congruent Numbers

A POSITIVE INTEGER NUMBER $n$ is said to be *congruent* if it is the area of a right triangle whose three sides are all rational numbers (ratios of integers). This usage of "congruent" should not be confused with other usages of the word in mathematics. The congruent number problem is to determine if a number $n$ is congruent and, if so, to find one or more right triangles with area $n$ and rational sides. This problem dates back to at least the tenth century when it is described in an Arab manuscript of the period [1].

The congruent number one often thinks of first is 6 because the well-known right triangle with sides 3, 4, and 5 has area 6. By the way, the right triangle with sides 7/10, 120/7, and 1201/70 also has area 6.

Fermat showed in 1640 that 1 is not congruent, and he invented a whole new method of proof, called the method of descent, to show this [2]. This result is important because it shows that no perfect square $k^2$ can be congruent. For if $k^2$ were the area of a right triangle with rational sides $a$, $b$, and $c$, then the right triangle with sides $a/k$, $b/k$, and $c/k$ would have area 1, a contradiction.

It is natural for a lover of recreational mathematics to be curious about whether recent years are congruent, so we investigate this.

## 2018

Is 2018 a congruent number? After much searching without success for a right triangle with area 2018 and rational sides, we decided to see if there were a way to show 2018 is *not* congruent. Note that $2018 = 2 \times 1009$ where 2 and 1009 are prime. In particular, 2018 is square-free, that is, not divisible by the square of any prime.

To show 2018 is not congruent, an important result called Tunnell's theorem [2], [4] comes to our rescue. This theorem requires sophisticated algebraic geometry to prove, but fortunately is not hard to apply. For a square-free even number $n$, let $h(n)$ be the number of integer triples $x, y, z$ that satisfy $x^2 + 4y^2 + 8z^2 = n/2$. Let $k(n)$ be the number of integer triples $x, y, z$ that satisfy $x^2 + 4y^2 + 32z^2 = n/2$. Tunnell's theorem tells us that if $h(n) \neq 2k(n)$, then $n$ is not congruent. Computer calculations show that $h(2018) = 56$ and $k(2018) = 20$ so 2018 is not congruent.

## 2019

Now let's ask, is 2019 a congruent number? As with 2018, we searched in vain for a right triangle with area 2019 and rational sides. Now $2019 = 3 \times 673$ where 3 and 673 are prime. So 2019 is square-free.

Tunnell's theorem also covers this case. For a square-free odd number $n$, let $f(n)$ be the number of integer triples $x, y, z$ that satisfy $x^2 + 2y^2 + 8z^2 = n$. Let $g(n)$ be the number of integer triples $x, y, z$ that satisfy $x^2 + 2y^2 + 32z^2 = n$. Tunnell's theorem tells us that if $f(n) \neq 2g(n)$, then $n$ is not congruent. Computer calculations show that $f(2019) = 192$ and $g(2019) = 88$ so 2019 is not congruent.

## 2020

Finally, let's hope 2020 is congruent. We have $2020 = 2^2 \times 5 \times 101$, where 2, 5, and 101 are primes, so 2020 is not square-free but $505 (5 \times 101)$ is. We will search for a right triangle with rational sides $a$, $b$, and $c$ and area 505. If we find one, then $2a$, $2b$, and $2c$ will be the rational sides of a right triangle with area 2020. Eureka! After a computer search of all triples of rational numbers where the shortest side is a multiple of 1/1000 and the numbers form a right triangle with area 505 (see Appendix), we found $a = 2020/99$, $b = 99/2$, and $c = 10601/198$. The right triangle with sides $2a = 4040/99$, $2b = 99$, and $2c = 10601/99$, therefore, has rational sides and area 2020. So 2020 is congruent!

## Appendix

In this Appendix we discuss how to do a search that, if successful, will determine that a number $n$ is congruent.

Consider a right triangle with rational length sides and area $n$, a positive integer. Let the sides have length $a$, $b$, $c$ where $a \leq b \leq c$. Then the triangle has area $n = a \times b / 2$ so $b = 2\ n / a$. Also, because it is a right triangle, $c = (a^2 + b^2)^{1/2}$. Note that $b$ will be rational if $a$ is, but $c$ may not be.

Because $n = a \times b / 2 \geq a^2 / 2$, we have $a \leq (2n)^{1/2}$, a fact that will be used below.

In order to ensure that the process terminates, we restrict the denominator of $a$ (when written as a fraction in lowest terms) to be at most $d_{MAX}$ where $d_{MAX}$ is a positive integer specified in advance.

The steps in the search are as follows:

Initialize $d$ to 1. ($d$ will be the denominator of $a$.)
Initialize $t$ to 1. ($t$ will be the numerator of $a$.)

(*) Set $a = t / d$ and $b = 2\ n / a$.

Determine a common denominator $D$ for $a$ and $b$. Then we can write $a = a_1 / D$ and

$b = b_1 / D$ where $a_1$ and $b_1$ are integers.

Check to see if $c_0 = (a_1^2 + b_1^2)^{1/2}$ is an integer. If so, then $c = c_0 / D$ is the rational length of the hypotenuse and $n$ is congruent. (We may stop here.)

If not and $a < (2n)^{1/2}$, increase $t$ by 1 and go to (*).

Else if $d = d_{MAX}$, stop. (There is no solution subject to the restriction on the size of the denominator of $a$.)

Otherwise, increase $d$ by 1, set $t$ to 1, and go to (*).

It should be emphasized that failure to find a solution for $n$ does not prove that $n$ is not congruent. Stein [3], crediting Zagier, gives $n = 157$ as a congruent number whose congruence cannot be verified by any simple computer search in reasonable time.

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# Pentamorphic, Octamorphic, and Nonamorphic Numbers Derive from Automorphic Numbers

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## Abstract

*Automorphic* numbers are defined and their properties reviewed. We then show that the *pentamorphic*, *octamorphic*, and *nonamorphic* numbers studied by Trigg and more recently by Ashbacher are closely related to the automorphic numbers.

## Automorphic Numbers

**In [1] Madachy introduces the concept** of an *automorphic* number. A number is automorphic if its square ends in the digits of the number itself. So, for example, 625 is automorphic because $\mathbf{625}^2 = 390\mathbf{625}$. If a number $n$ has $d$ digits (in base 10), it is automorphic if

$$n = n^2 \bmod 10^d.$$

Much is now known about automorphic numbers. There are two classes of them (greater than 1): Those ending in the digit 5 and those ending in the digit 6. Let us look at those ending in 5 first. They can be listed as follows (from [2]):

5, 25, 625, 0625, 90625, 890625, 2890625, 12890625, 212890625, 8212890625,...

Notice that we treat 625 and 0625 as if they were distinct numbers. With this convention, there is exactly one $d$-digit automorphic number in this class for each positive integer $d$ (see [4]). Moreover, for $d > 1$, the $d$-digit automorphic number in the class has the same last $d - 1$ digits as the $(d - 1)$-digit number in the class. From [2] the $d$-digit automorphic numbers $a_d$ ending in 5 are defined by

$$a_d = 5^{2^d} \bmod 10^d.$$

The properties of the automorphic numbers ending in 6 are very similar. From [3] they can be listed as:

6, 76, 376, 9376, 09376, 109376, 7109376, 87109376, 787109376, 1787109376, ...

From [3] the $d$-digit automorphic numbers $b_d$ ending in 6 are defined by

$$b_d = 16^{5^d} \bmod 10^d.$$

## Pentamorphic Numbers

The *pentagonal* numbers are numbers of the form $P(n) = n(3n - 1)/2$ for positive integers $n$. These numbers are related to the pentagon as follows: For $n = 1$, $P(1) = 1$. For $n = 2$, $P(2) = 5$, corresponding to the number of dots on the smaller pentagon in Figure 1. For $n = 3$, $P(3) = 12$, corresponding to the number of dots on both pentagons in Figure 1, and this pattern continues for larger $n$.

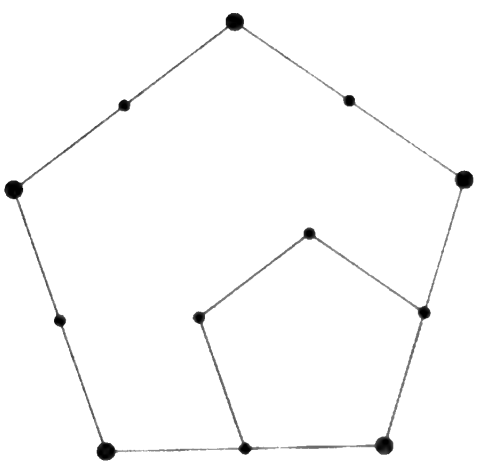

**Figure 1: Pentagonal Numbers**

In [5] Charles W. Trigg defined *pentamorphic* numbers to be pentagonal numbers whose digits end in the digits of $n$. For example, $P(\mathbf{625}) = 625(3\times625 - 1)/2 = 585\mathbf{625}$ so 585625 is pentamorphic. Recently, Charles Ashbacher in [6] further studied these numbers. We will show that if $P(n)$ is pentamorphic, then $n$ must be automorphic.

If $P(n)$ is pentamorphic and $n$ has $d$ digits, then $P(n) = n \bmod 10^d$, so

$$n(3n - 1)/2 = n \bmod 10^d,$$
$$n(3n - 1) = 2n \bmod 10^d,$$
$$3n^2 - n = 2n \bmod 10^d,$$
$$3n^2 = 3n \bmod 10^d,$$
$$n^2 = n \bmod 10^d,$$

showing that $n$ is automorphic. The last step above (dividing both sides of the equation by 3) is justified because 3 and $10^d$ are relatively prime (coprime).

We have shown that if $P(n)$ is pentamorphic, then $n$ is automorphic, but the converse may fail. The examples less than a million are $P(6) = 51$, $P(76) = 8626$, $P(376) = 211876$, and $P(109376) = 17944609376$. Note that in these examples $P(n)$ fails to be pentamorphic by only one digit.

## Octamorphic Numbers

The *octagonal* numbers are numbers of the form $E(n) = n(3n - 2)$ for positive integers $n$. These numbers are related to the octagon as follows: For $n = 1$, $E(1) = 1$. For $n = 2$, $E(2) = 8$, corresponding to the number of dots on the smaller octagon in Figure 2. For $n = 3$, $E(3) = 21$, corresponding to the number of dots on both octagons in Figure 2, and this pattern continues for larger $n$.

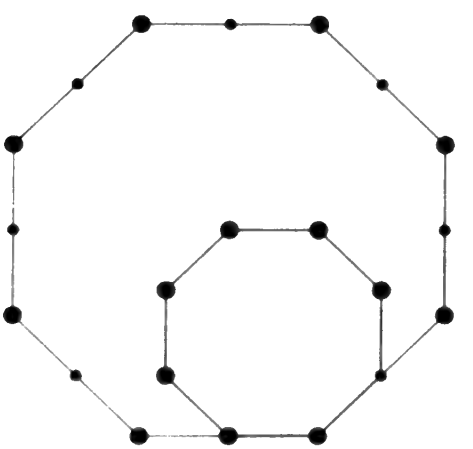

**Figure 2: Octagonal Numbers**

In [7] Trigg defined *octamorphic* numbers to be octagonal numbers whose digits end in the digits of $n$. For example, $E(376) = 376(3\times376 - 2) = 423376$ so 423376 is octamorphic. Ashbacher in [8] further explored these numbers. We will show that $E(n)$ is octamorphic if and only if $n$ is automorphic.

If $E(n)$ is octamorphic and $n$ has $d$ digits, then $E(n) = n \bmod 10^d$, so

$$n(3n - 2) = n \bmod 10^d,$$
$$3n^2 - 2n = n \bmod 10^d,$$
$$3n^2 = 3n \bmod 10^d,$$
$$n^2 = n \bmod 10^d,$$

showing that $n$ is automorphic. The last step above (dividing both sides of the equation by 3) is justified because 3 and $10^d$ are relatively prime. The steps can be reversed to show that if $n$ is automorphic, then $E(n)$ is octamorphic.

In response to questions posed in [8] there are infinitely many octamorphic numbers because there are infinitely many automorphic numbers. Moreover, because the octamorphic numbers $E(n)$ have the same trailing digits as $n$, they will have the same patterns of trailing digits as the automorphic numbers.

## Nonamorphic Numbers

The *nonagonal* numbers are numbers of the form $N(n) = n(7n - 5)/2$ for positive integers $n$. These numbers are related to the nonagon (nine-sided polygon) as follows: For $n = 1$, $N(1) = 1$. For $n = 2$, $N(2) = 9$, corresponding to the number of dots on the smaller nonagon in Figure 3. For $n = 3$, $N(3) = 24$, corresponding to the number of dots on both nonagons in Figure 3, and this pattern continues for larger $n$.

In [9] Trigg defined *nonamorphic* numbers to be nonagonal numbers whose digits end in the digits of $n$. For example, $N(625) = 625(7\times625 - 5)/2 = 1365625$ so 1365625 is nonamorphic. Ashbacher in [10] also investigated these numbers. We will show that if $N(n)$ is nonamorphic, then $n$ must be automorphic.

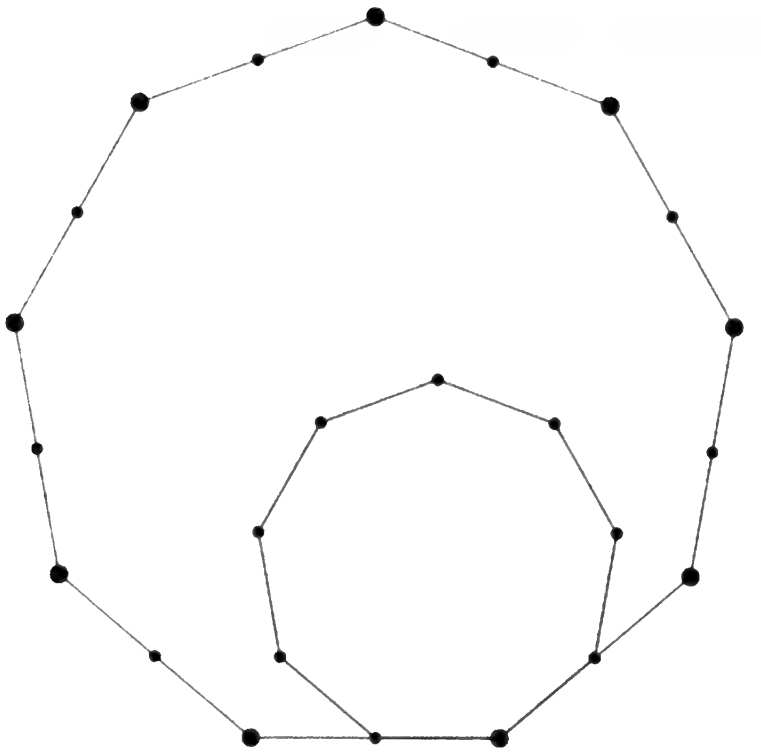

**Figure 3: Nonagonal Numbers**

If $N(n)$ is nonamorphic and $n$ has $d$ digits, then $N(n) = n \bmod 10^d$, so

$$n(7n - 5)/2 = n \bmod 10^d,$$
$$7n^2 - 5n = 2n \bmod 10^d,$$
$$7n^2 = 7n \bmod 10^d,$$
$$n^2 = n \bmod 10^d,$$

showing that $n$ is automorphic. The last step above (dividing both sides of the equation by 7) is justified because 7 and $10^d$ are relatively prime.

We have shown that if $N(n)$ is nonamorphic, then $n$ is automorphic, but the converse may fail. The examples less than a million are $N(6) = 111$, $N(76) = 20026$, $N(376) = 493876$, and $N(109376) = 41870609376$. Notice that in these examples $N(n)$ fails to be nonamorphic by only one digit. Furthermore, these are the same exceptional automorphic numbers $n$ that we had for pentamorphic numbers.

## Remaining Questions

We have shown that $E(n)$ is octamorphic if and only if $n$ is automorphic. Because we know much about automorphic numbers, this tells us much about octamorphic ones. In particular we know there are infinitely many.

For pentamorphic and nonamorphic numbers, the situation is not so clear. We know that $n$ may be automorphic yet $P(n)$ fail to be pentamorphic and $N(n)$ fail to be nonamorphic.

If $n$ is an automorphic number ending in a 5, must $P(n)$ be pentamorphic and $N(n)$ be nonamorphic? If $n$ is an automorphic number ending in a 6, is there a pattern for when $P(n)$ is pentamorphic and $N(n)$ is nonamorphic?

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# INNOVATION IN REGULATORY SCIENCE ASSESSMENT OF RETRACTIONS OF PUBLISHED PAPERS

Alan Moghissi [1,2], Richard A. Calderone[1], Jean Pierre Auffret[1,3], Dennis K. McBride[2], David Harrison [2] , John Campbell[1], Camille Estupigan[1], Maggie Fu[1], Rae Koch[1], Catharine Leahy[1], Hajer Mazagri[1], Ogechi, Nwaopara[1], Dania Shafei[1], Sarah Sheppard[1], Vanessa Vanderdys[1], Mengdan Zhao[1], and Tomoko Y Steen[1]

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## ABSTRACT

Peer review is a key element in the acceptability of a scientific claim. However, as currently performed, certain shortcomings have led to proposals for alternative to peer review. This paper examines cases of peer review processes and the causes for retractions of papers published in peer-reviewed journals. This study uses Metrics for Evaluation of Regulatory Science Claims (MERSC) based on Best Available Regulatory Science (BARS) principles to address the causes of retractions. The study attributes the causes of retraction primarily to the level of maturity of science as described in BARS/MERSC and to errors from authors for manipulation of data, republication, plagiarism, biased peer review, and violation of ethical rules. Furthermore, other causes of retraction include revealed bias of the editors of the journals, poor review processes, and the undisclosed business interests of journals to publish papers, regardless of their quality. This paper provides examples of retracted papers and their causes. This study also proposes the establishment of an international review board with the working title, International Peer Review Committee (IPRC), to set standards for the editorial offices of scientific journals on how to identify and select qualified reviewers.

## INTRODUCTION

**INDEPENDENT PEER REVIEW** is a key element in the validation of scientific claims, including regulatory science claims. Over the past several decades many peer reviewed studies have shown to be unsatisfactory, not reproducible, or false. Investigators, authors, editors, and members of the media have pointed out retracted papers as evidence that the peer review process can be flawed and should be improved before using to prove certain scientific claims. An Internet search on February of 2020 identified over 17 million results for the phrase 'advantages and disadvantages of peer review', and over 19 million results for the search term 'shortcomings of peer review'. There is a widespread view that peer review is flawed, even when peer review is correctly performed. Widener (2018) describes problems of currently performed peer review, McCook (2018) identified one publisher who had more than 7,000 retractions, and Oransky (2018) provided a list of countries with the highest rate of retractions in their publications. Richard Smith, the former editor of *British Medical Journal,* claimed that peer review is a flawed process (2006); Wager and Jefferson (2001) addressed problems related to publications in biomedical journals; and Newton (2010) discussed the key role of editors in scientific publishing.

Moghissi, *et al.* (2013) compared the peer review process to the *jury of peers* practice common in the Anglo-American judicial system, which requires individuals who are independent to judge the validity of claims made by a prosecutor in a legal case. However, many cases decided by a jury of peers have been proven wrong (Parker, et al. 2003).

Shortcomings in the publication process used by certain journals provide a key reason for the retraction of published papers. Editors are legally, ethically, and morally responsible for published materials in their journal. Unfortunately. on occasion editors violate the ethical rules governing the publication process resulting in retraction of published papers. Traditionally, many journals have a list of reviewers and the list was periodically updated. Meanwhile, the number of journals has skyrocketed and currently many journals do not provide a list of reviewers. Frequently, journals ask authors to identify peer reviewers for the manuscripts they have submitted but this practice represents a conflict of interest, as authors are unlikely to identify reviewers who do not agree with their approach or vision. In other cases, critical comments and revision recommendations that

have been submitted by a reviewer may be ignored, as was the case with an article by Gordon, *et al.* (1997). According to Moghissi, *et al.* (2013), three reviewers were asked to evaluate Gordon's article. The reviewers provided comments for revision, and all three reviewers recommended rejecting the submission, as its publication would adversely impact the Endangered Species Act (ESA). The editor asked the manuscript's authors to consider the comments of the reviewers and the journal eventually accepted and published the paper. The publication of that paper resulted in significant impact, including certain revisions of public law.

Kuroki and Ukawa (2018) used the *power law*, a statistical process common to several branches of science, to evaluate the status of the retraction of papers. Their methodology revealed that a small fraction of authors are responsible for about 10% of annual retractions; after about five-years, 3-5% of those authors are likely to incur additional retractions; and after an additional five-years, that same subset is responsible for 26-37% of overall retractions. Several cases demonstrate the validity of Kuroki and Ukawa's claim. For example, in 2018, the Journal of the *American Medical Association* (JAMA) asked Cornell University to independently evaluate several papers published by nutrition scientist, Brian Wansink, after JAMA's editor, Howard Bauchner, identified several problems with Wansink's research. As discussed in this paper, in the wake of this episode, an evaluation of alternative methods to the current "independent" peer review revealed several options for publishers to consider.

There has been debate on the acceptability of fees paid for publications resulting from studies funded by the United States government. Traditionally, publishers receive their income by subscriptions paid by libraries and various private users, and to collect fees for reprints of published papers. In contrast open-access publications provide these services free of charge, thus substantially decreasing the necessity for subscription fees. This debate was reflected in the Emerson Amendment, a short addition to an Appropriation Act in 2001, which required the Office of Management and Budget (OMB) to develop a peer review process for federal agencies. The details of the Emerson Amendment and its OMB-related activities were published in 2003 and finalized in 2005. Eventually, the OMB published a *bulletin* (2005) on peer review. The bulletin asked federal agencies to either comply with its recommendations, or to develop

their own process in compliance with the OMB bulletin. In anticipation of this new peer review process, the National Institutes of Health (NIH) director, Elias Zerhouni (2004), published an article suggesting that NIH-funded research should be made available to the public. This recommendation led to the NIH's open access policy.

Meanwhile, the desirability of open-access publications has spread globally, notably in Europe. The European Union (Science Europe, 2018) has decided to provide free access to certain scientific publications to the European community. The project, known as Plan S, is currently in progress. The subject is rather complex and somewhat beyond the scope of this study. One wonders, rhetorically, if Albert Einstein would have been able to publish his papers including his paper on light while he was an employee at the Swiss patent office in Bern, Switzerland (Einstein 2005).

One of the potential side effects of the open-access process is the evolution of predatory journals whose primary objective is different than serving the scientific community. As described by Richtig *et al* (2018) the subject is complex and should be addressed by the scientific community. There is an increasing number of journals that claim to have high Impact Factors or convey other false claims. It is imperative to recognize the difference between legitimate open-access journals and predatory journals.

Several studies question the value of the peer review process and provide potential alternatives steps. In this paper we summarize three options:

1. The first option which is commonly used is to publish all papers when they are submitted, by assessing the reliability of scientific claims according to the reputation of the researchers and/or organizations that conduct the studies. The advantage of this approach might be both economical and reduce the publication time. This process has been common in continental Europe up to the mid-twentieth century. The disadvantage of this method is that it is virtually impossible for young and lesser known investigators to publish their papers, regardless of how innovative and important their work may be, also known as the *Matthew Effect* (Merton 1968).
2. The second option establishes the validity of the results of the study by reproducibility, which is consistent with the historic scientific

method as outlined by Sir Robert Boyle in the 17th century (Boyle 1661). In this method a paper is published once the claims of its authors have been independently reproduced and verified. The shortcoming of this process is that it requires contemporary interest and funding from an independent organization to reproduce a scientific claim made by another organization. To this end several attempts have been made to ask authors or interested parties to fund the reproduction of a study. For example, the *Validation Science Exchange* has promoted its *Reproducibility Initiative* best practices for over half a decade to guide investigators in the reproduction of study results. However, the *Validation Science Exchange* concedes that funding must be provided by the original study author(s), or by another source. Unfortunately, the total number of scientific papers published annually is so large that it is impractical to attempt to reproduce all of them. Many publications lack reproducibility even after they have been peer reviewed. Baker (2016) published the results of 1,576 researchers who were surveyed about their views on the reproducibility of published papers. Almost 90% of the respondents agreed that there was a significant (52%) or slight (38%) "crisis" in the reproducibility of scientific studies. Although Goodman & Greenland (2007) questioned the Ioannidis's statistical analysis, Ioannidis (2005) provided statistical evidence that "most published research findings (in medical journals) are false". Goodman and Greenland considered only those studies that evaluated association versus causation, which poses problems with their methodology, because a significant number of studies performed across scientific disciplines are, in fact, reproducible.

3. Although there are several versions of the third option, virtually all versions embrace the idea of publishing every paper by submitting it on the World Wide Web, to be openly accessed by everyone. Proponents of this approach claim that once authors make their paper available, their disciplinary peers will provide relevant comments, which will allow the larger scientific community to judge the validity of the paper's claims.

A description of details of peer review in scientific publishing is beyond the scope of this paper. The book by Moghissi *et al.* (2013) provides

relevant information. In addition, there have been significant improvements in peer review by funding agencies, such as the National Science Foundation (2019) and the National Institutes of Health (2019). It is recognized that the peer review process continues to evolve, and the process used by these and certain other agencies are periodically updated.

This paper represents a continuation of previous studies performed by graduate students who participated in a regulatory science course at Georgetown University. In a previous study Moghissi, *et al.* (2015) identified the role of review criteria in an overview of shortcomings in the peer review process. The students were asked to identify categories of retracted papers and to reference evidence of at least one retracted paper in each category. This study was not intended to provide a comprehensive accounting of all retractions, withdrawal, or similar actions. Instead, the research team identified specific retracted papers, determined the causes of the retractions, and then referenced the reasons stated by the journal for issuing the retraction.

## ASSESSMENT PROCESS

The assessment process in this study consists of the *Best Available Regulatory Science* (BARS) best practice and the *Metrics for Evaluation of Regulatory Science Claims* (MERSC) that are developed from BARS (Moghissi, *et al.*, 2017), a process used in several publications. In order to facilitate the application of BARS/MERSC BARS its details are briefly described. BARS consists of five principles and MERSC includes three pillars derived from BARS principles. Figure 1 provides an overview of the BARS/MERSC system.

### Summary of five BARS Principles

1. Principles on *Open mindedness* and (2) *Skepticism* imply that the scientific community must be open minded and consider a scientific claim. However, those who make a claim must provide sufficient evidence supporting their claim.
2. The *Scientific Rules Principle* is well known and its description beyond the scope of tis paper. However, violation of this principle is one of the primary causes of retractions.
3. The *Ethical Rules Principle* requires truthfulness, communicability, transparency, and standards of morality. According to this principle

those who make a claim must describe any assumption and judgment as well as if they have included any default data in their claim. They must be also truthful and must follow morality requirements

4. The *Reproducibility Principle* implies that the ultimate objective of a scientific claim is reproducibility. In effect this principle requires that anyone with relevant knowledge, needed equipment, and necessary facilities could reproduce the claim.

**Summary of three MERSC Pillars**

1. The *Classification of Regulatory Science* pillar provides a framework to determine the level of maturity of science starts with scientific laws and their proper applications. The next two groups in this pillar (Evolving and Judgement) are most often applied in regulatory science applications. The level of scientific maturity of each class in these two groups decrease from Reproducible to Speculation. Arguably, when an investigator makes a poor judgment or unfounded speculations on a project, it is not only possible, but likely that another investigator may reach a different conclusion.
2. The pillar on Reliability of regulatory science provides several categories of scientific claim ranging from personal opinion to consensus processed regulatory science. Due to the repeated occurrence of withdrawal of peer-reviewed papers it is desirable to require verification of studies that will be used in the regulatory process. The level reliability of a scientific claim starts with personal opinions, which is formalized in a report commonly known as gray literature. The first and a key step is independent peer review. The verification of a claim is increasingly recognized as key element in regulatory science claims. Consensus Process, the last step in the reliability process is a key element of regulatory science as it provides the likelihood of acceptability of a scientific claim used in the regulatory process.
3. *Areas outside the Purview of Science* (OPS) pillar include ideology, religious objectives, policy goals, and other societal considerations or traditions that may influence the formation of a scientific conclusion. A case included in this pillar, for example, is publication of a paper that may be associated with the financial interests of the publisher, the

need to satisfy minimum article counts to meet publication deadlines, or other *non-scientific* reasons.

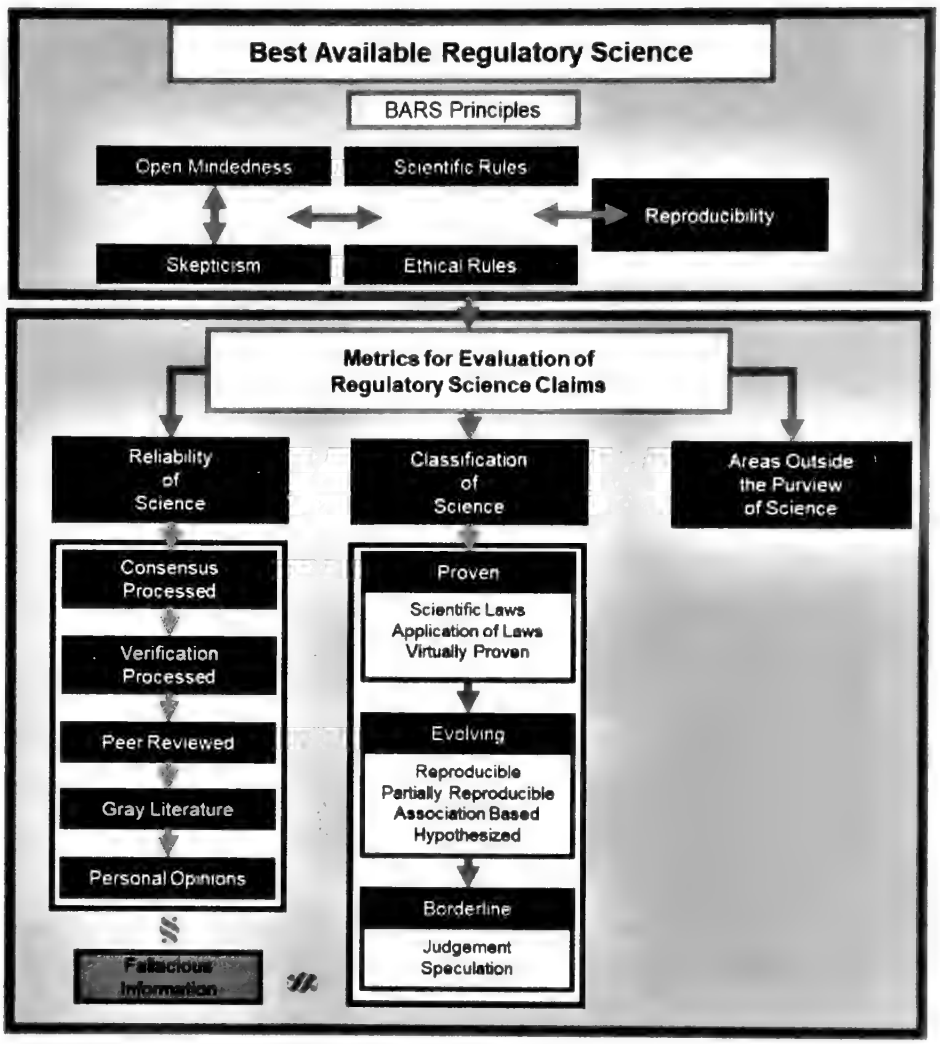


Figure 1. Best Available Regulatory Science and Metrics for Evaluation of Regulatory Science Claims

## RESULTS

Several attempts were made to categorize the causes for the retraction of published papers. The final categorization of retracted papers led to the identification of four categories: (1) the role of the editor, (2) the role of the authors, and (3) the role of reviewers and 4) other unclassifiable problems.

## 1. The Role of the Editor

As described in this paper, the editor is legally, ethically, and morally responsible for accepting, rejecting, or asking for revision of a submitted manuscript. There is evidence that in certain cases, an editor's decision is based on non-scientific reasons, such as bias, ideology, financial interest, meeting the publication schedule, or other reasons. Examples are referenced in this category to demonstrate the point.

A most unfortunate case of apparent editorial bias is the publication of a paper published in the *Lancet,* a well-known medical journal. The paper by Wakefield, *et al.* (1998) claimed that the vaccination of measles, mumps, and rubella (MMR) caused autism in vaccinated children. As described by Moghissi, *et al.* (2013) the Wakefield publication was not only scientifically flawed, it had also significant adverse consequences to society and the medical community, because many parents used that paper as evidence to avoid vaccinating their children. There were several letters to the *Lancet's* editor disputing Wakefield's claims, and the authors eventually conceded that they could not find a correlation between the MMR vaccine and autism. In 2004, Horton, the editor of the *Lancet* published a book describing the reason for having published those papers, which led to their subsequent retraction in 2010. Eventually, the paper was retracted and there were adverse professional consequences for the senior author, as well as others who referenced the paper in support of their anti-vaccination claims.

**Conflict of Interest: Business interests of the journal:** Acharya, *et al.* (2008) published a paper that was withdrawn because the business interest of the authors was inadequately considered.

**Error in the Acceptance of Submissions:** A paper submitted by Palma and Ferreira (2013) was retracted because the Editor in Chief accidentally accepted it while the reviewers recommended to reject it

## 2. Retraction Caused by Errors of Authors:

A large fraction of retracted papers was caused by errors or fabrications made by the authors, examples follow:

**Fabrication of Coauthors:** Deng *et al.* (2014) identified fabricated identities and impersonation of individuals, which subsequently caused the

papers to be retracted. Similarly, Blanco *et al.* (2006) were accused by adding a co-author (Grande) who did not participate in the study.

**False Peer Review:** There are many scientific papers that have been withdrawn because they used fake peer review. For example, Canning and Bayness (2015) reported that 64 articles in a journal published by Springer Verlag were withdrawn because of fake peer reviews. Similarly, Kumar *et al* (2016) published a paper that was withdrawn because of the accusation of fake peer review in related papers by the same authors. As another example, a paper by Yan *et al* (2015) was retracted because of false peer review.

**Faulty Methodology** López-Medrano *et al* (2016) published a paper that included faulty methodology. Peer review should have detected the error, but it was not identified until much later. In addition, a research article on SARS-CoV-2 by Wang *et al* (2020) was published after a hasty acceptance by the journal and was retracted after whistleblowers flagged the article's faulty methodology. A study conducted by Liu *et al* (2019) was discovered to have used unreliable methods.

**Manipulation of Data:** A paper by Dunoyer *et al.* (2004) on RNA silencing was retracted because the authors admitted to inappropriate manipulation of images used. Furthermore, Darinskas *et al* (2017) published a study that was retracted when an investigation indicated that patients and data of the study could not be located or verified. Similarly, a paper on the neurological impact of flavors (Geraedts and Munger, 2013) was retracted because of data fabrication and manipulation.

**Misconduct:** A well-known case was the publications by Paolo Macchirini, a surgeon who was employed at the Karolinska Institute in Stockholm. As described by Abbott (2018), six articles co-authored by Macchirini were withdrawn because of distorted descriptions of the patients participating in the studies. The descriptions were the foundation of the published articles. Additionally, Niitsu *et al* (2010) provides another example of misconduct from a conducted research study analyzing 314 lymphoma patients being treated with chemotherapy. An investigation by Niitsu *et al* indicated no consent from the patients and lack of approval by the Institutional Review Board. Another example is Wang *et al* (2012) that was retracted due to inadequate oversight and fabrication of data.

**Plagiarism:** A relevant example is the case study of Dasinger, who submitted a paper to the *Annals of Internal Medicine* for review and that manuscript was rejected. Subsequently, Finelli *et al.* (2016) published a slightly modified version of the same article that was published and then eventually retracted. Another case consisted of a review article by Ali *et al* (2018) that was published and retracted for plagiarism of a similar article. What was unique about this retraction was that journal's plagiarism check software was unable to detect the duplications in the paper (Cureus, 2019).

**Republication:** A slightly modified version of a paper published by Arun (2013) was coauthored by Katiyar (2013) and submitted to other journals. Ling *et al.* (2019) published a paper originally published in Chinese leading to the retraction of the republished paper. In a similar case Ling *et al* (2018) published a paper in *Biomolecules* that was withdrawn after it was discovered that the paper was published by the same authors in Chinese. As a final point towards retractions caused by republication, a distinguished psychology researcher, Robert J. Sternberg has been criticized for reusing his own content verbatim in multiple publications. As a result, his research article (Sternberg, 2010) was withdrawn albeit the scientific content of the article was legitimate. The current process considers republication to be unethical regardless if the republication is in the original or a different language. It is desirable to make a distinction between publishing the same paper with the objective to increase the number of published papers and translating a paper to make its content available to a larger audience.

**Violation of Ethical Rules:** La Sala *et al* (2015) published a paper claiming that the study was conducted with the appropriate ethical oversight. Subsequent investigation indicated that it was not. Lavhale *et al* (2009) published a research article involving tumor sizes in mice. This paper was later withdrawn because of violation of ethical rules (The PLOS ONE Editors, 2020). In another example, a paper by Kantevari *et al* (2011) was retracted due to a violation of the EUCheMS Ethical Guidelines for Publication in Journals and Re-views. Graham C. R. Ellis-Davies, a co-author of the paper, published the report without the consent of other co-authors; (Chemistry Europe, 2011).

**Multiple withdrawals:** One of the most unusual cases is the withdrawal of multiple papers from one or several authors. For example, based on the evaluation of the Office of Research Integrity (2020), there are seven papers

by Dr. Shin Hee Kim, an assistant professor at the University of Maryland that were withdrawn. The accusation used by peer review was that the professor knowingly and intentionally used falsified evidence or fabricated materials within the paper.

### 3. The Role of the Reviewers

Reviewers play a key role in providing the editor with the advice on the acceptability of a study and identifying shortcomings of the study published in a paper. As described in many books and instructions (*e.g*, Moghissi *et.al.* 2013), they must be qualified to evaluate the validity of the results of the study based on the details presented in the paper. They must be independent implying that they have no conflict of interest. Instructions for reviewers are typically included in journal websites and may or may not be comprehendible to reviewers. Similarly, in many cases, it is likely that qualified peer reviewers are unavailable to journals or the reviewers are not held accountable to be in compliance to the exact standard criteria that are required of a content expert who conducts an anonymous peer review evaluation.

### 4. Retraction for Reasons that were not Detectable

Arguably, the most well-known example of this category is a publication by Fleischmann and Pons (1989), who claimed to have achieved cold fusion of deuterium (an isotope of hydrogen) atoms at slightly above the room temperature. The paper provided details of the experiment performed by the authors. Given the enormous consequences of the study as described by Huizenga (1993), several investigators attempted to reproduce the claim and found it to be unsupported or categorically incorrect.

## DISCUSSION

Peer review is the foundation for validating scientific claims. Unfortunately, there are many shortcomings in the way some publications practice peer review. These shortcomings include inclusion of non-scientific subjects, such as policy goals, ideology, religious motives, and business-based decisions. There are numerous examples of publications that have caused public health and other harms.

The BARS/MERSC process provides a framework for identifying the potential reasons for a lack of reproducibility, as is expected in scientific

methodology. Often the level of maturity of science facilitates and may also limit experimental/empirical reproducibility. In contrast studies that attempt to apply scientific laws or incorporate the principles of *Reproducible Evolving Science* are more likely to be reproducible.

Based on the studies evaluated in this paper, it is likely that only a small fraction of publications containing issues of data integrity, process, or results are retracted. This study has identified and exemplified three major categories of reasons for manuscript retraction.

The first and primary reason for a retraction is caused by the editors of scientific journals. As said before editors are legally, morally, and ethically responsible for the accuracy of papers entrusted to them for publication under their ultimate approval. As described in this paper, many retractions are traceable to the performance of editors. However, there are several reasons that some poor-quality papers might be published that are beyond the control of the editor. As described above, the impact of an editor's societal objectives can be demonstrated by Wakefield, *et al.* (1998) paper.

Another key reason for the lack of reproducibility of a scientific claim is the level of maturity of science used in the paper, as described in Figure 1 on BARS/MERSC. For example if the conclusion of a paper engages a subject area that can be classified as *Borderline Science,* then it can likely to be disputed, which accounts for Ioannidis' (2005) claim that most published papers are invalid (2005). Ioannidis used the BARS/MERSC *Association-Based Evolving Science* framework to evaluate publications; he recognized that an association to an outcome does not imply direct causation. Even the most stringent peer review process cannot determine the validity of some claims. The examples included in this paper demonstrate how properly performed peer review could have prevented the retraction of most published papers. As described in BARS/MERSC, the recognition of the level of maturity of the applied underlying science, and compliance with the *Ethical Rules Principle* notably the exclusion of societal objectives could have reduced the number of publications that were retracted as unacceptable papers.

The evolution of open-access journals is highly desirable as many more investigators can access published information. The open- access process has caused changes in financial systems of publishers as often they

depend upon the number of published papers. For obvious reasons an open access journal is more likely than conventional journals to accept a paper with questionable content if the author pays the required publication cost. Open access journals have recognized the problem and have undertaken efforts to ensure the reliability of submitted content.

## CONCLUSIONS

The results of this study demonstrate that sometimes peer review sometimes fails and therefore there is a need for creation of a peer-based international organization that supports peer review of scientific journals. The entire scientific community would greatly benefit if all the scientific journals had access to qualified reviewers. A reasonable option would be to establish an international organization with the working title, *International Peer Review Committee* (IPRC), to provide access to qualified peer reviewers. While certain journals and other organizations maintain databases of reviewers, it is highly desirable to ensure cooperation among these organizations and the proposed IPRC to make available a pool of qualified reviewers, thereby enabling the reduction for the number of retractions. The formation of an IPRC should reduce the problem of retractions in scientific publications.

Another process would consist of evaluating the reproducibility of a study before it is submitted to a journal. For example, the funding organizations including government agencies could require such an approach resulting in significant reduction of retracted papers.

Finally, it is imperative that the scientific community recognizes the consequences of publishing flawed papers. Important distinctions should be made between a paper that is withdrawn because it contains previously published material and a paper that contains flawed information. Although both violate ethical rules, the latter category is not due to errors of honest oversight. It is a quality control problem that can and must be managed by rigorous peer review.

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## BIO

**A. Alan Moghissi** is currently president of the Institute for Regulatory Science, an adjunct Professor in School of Medicine at Georgetown University, Previously, he was Associate Vice President for Environmental Health and Safety at Temple University in Philadelphia, PA and Assistant Vice President for Environmental Health and Safety at the University of Maryland at Baltimore. As a charter member of the U.S. Environmental Protection Agency (EPA), he served in several capacities, including Principal Science Advisor for Radiation and Hazardous Materials and Manager of the Health and Environmental Risk Analysis Program. He was a visiting professor at Georgia Tech, University of Virginia, and a professor of Medicine at the University of Maryland. He has been credited for the establishment of regulatory science discipline while at the EPA leading to the establishment of the Institute for Regulatory Science in 1985. He has published over 400 papers, 25 books, and was the editor-in- chief of three major scientific journals. He is the recipient of the EPA distinguished carrier award, an honorary member of the National Council on Radiation Protection and Measurements, an Academic Councilor of the Russian Academy of Engineering, and a fellow of American Society of Mechanical Engineers. He was appointed by the Secretary of State as a Commissioner of the United States UNESCO Commission. He received his education at the University of Zurich and federal Institute of Technology, Switzerland, and Karlsruhe Institute of Technology in Germany, where he received a doctorate degree in physical chemistry.

**Richard Calderone** has spent the past 45 years at the Georgetown University Medical Center (GUMC). Currently, he is the Chair of the Department of Microbiology & Immunology and continue to teach MS, PhD, and Medical Students. He and his research lab PhD and post-doctoral students have published over 140 scientific papers, chapters and books on fungal infections with special emphasis on research focusing upon the molecular biology of fungal pathogens including *Candida species*. Research in the lab has changed significantly in regard to approaches. Early on, because of a lack of molecular biology techniques, we characterized some of the biochemical factors that influence virulence of this human pathogen. His current research focuses upon using molecular biology and bioinformatics to identify gene targets that suggest an application to antifungal drug discovery. He has served as an editor/reviewer of numerous journal submissions and

served two four-year terms on research study sections at the NIH as well as a number of ad hoc research review groups. He has been a member of the American Society for Microbiology & Immunology, as a President of the Medical Mycology Section Division F, and he is a member of The American Academy of Microbiology and served as a past president of the Medical Mycology Society Association. He was one of the founders of Conferences on Candida and Candidiasis. He developed an MS degree Program in Biomedical Science Policy and Advocacy that has graduated over 100 students. In this capacity he has been lucky enough to collaborate with faculty to publish several papers related to "Regulatory Science."

**Jean-Pierre Auffret** is co-founder and president of the International Academy of CIO, an NGO headquartered in Tokyo, Japan with the objectives of fostering the exchange and adoption of best practices on CIO and IT executive leadership; and government IT institutions and organizations. He is also director, Center for Assurance Research and Engineering (CARE) in the Volgenau School of Engineering and director, Research Partnerships in the School of Business at George Mason University and a visiting lecturer in the Duke University Center for International Development. His work and research span a range of applied technology fields including on CIO and ICT leadership and governance and cybersecurity and including with APEC, NSF, IBM and World Bank. He has served on several Commonwealth of Virginia commissions including the Commonwealth of Virginia Health Information Technology Advisory Commission. He has 30 years of technology industry and academic experience including executive positions with MCI and its joint venture with British Telecom, Concert and academic positions with George Mason, Duke and American University. He earned a B.S. degree from Duke University where he was an A.B. Duke Scholar, an M.B.A. from the University of Virginia and a Ph.D. in Physics from American University.

**Dennis McBride** received the Ph.D. from the University of Georgia, in experimental psychology, with concentration in the mathematical modeling of the acquisition perceptuomotor skill in H. sapiens. He graduated post-doctorally from the Naval Aerospace Medical Institute and served a twenty year career as a Naval Aerospace Experimental Psychologist, with tours in five highly advanced R&D laboratories, and three national research

agencies, including the Defense Advanced Research Projects Agency. He earned post-doctoral master's degrees from the Viterbi School of Engineering - University of Southern California, Troy State University, and completed M.Phil. studies at the London School of Economics. He served as professor, with dual appointments in departments of engineering and psychology at the University of Central Florida where he was also Director of the Institute for Simulation and Training. He subsequently served for ten years as president of the Potomac Institute for Policy Studies (now president emeritus), and currently as Vice President of the Institute of Regulatory Science, adjunct professor at Georgetown University Medical School and Public Policy Institute, Vice President for Innovation at Source America, and Chief Strategy Officer / Senior Scientist at NeuroRx Pharma, a small molecule, clinical phase development company.

## Science Bite: Citizen Science and an Asteroid

Citizen science is scientific research conducted, in whole or in part, by amateur (or nonprofessional) scientists. Zooniverse (https://www.zooniverse.org/) is a popular site for citizen participation in scientific research.

In Hmedabad, India two fourteen year old girls recently discovered a previously unknown Earth-bound asteroid. They had poured through images from a University of Hawaii telescope (the Pan-STARRS telescope – the Panoramic Survey Telescope and Rapid Response System). The two girls attend SPACE India, a private institute. The SPACE India Institute is one of the few private space education initiatives in India.

The two girls, who come from the western city of Surat, discovered the asteroid as part of an asteroid search campaign conducted by SPACE India along with the International Astronomical Search Collaboration (IASC), a NASA-affiliated citizen scientist group. IASC Director J. Patrick Miller confirmed the discovery.

The girls used specialized software to analyze the images snapped by the Pan-STARRS telescope at the Haleakalā High Altitude Observatory Site, located on the island of Maui in Hawaii, and made the discovery in June.

The asteroid is presently near Mars. Its orbit is expected to cross that of Earth in about one million years' time.

"I look forward to... when we will get a chance to name the asteroid," said Vaidehi Vekariya, who added that she wants to become an astronaut when she is older. The person or people who discover(s) an asteroid can submit a name for it to the International Astronomical Union (IAU). The IAU is the body responsible for authorizing names for celestial objects. The asteroid's temporary name is HLV2514.

Radhika Lakhani, the other student, said she was working hard on her education. "I don't even have a TV at home, so that I can concentrate on my studies."

Asteroids pose a potential threat to Earth. In 2013, for example, an asteroid heavier than the Eiffel Tower exploded over central Russia, leaving more than 1,000 people injured from its shockwave.

**News Release**
**Washington Academy of Sciences Announces 2020 Awards**

The Washington Academy of Sciences is pleased to announce its 2020 awards to recognize work of merit and distinction of scientists and leaders in the greater Washington area. We had some outstanding nominations and pleased to point out that we have the largest number of women awardees for the year in the history of the academy. These awards will be presented at our Annual Awards Banquet Ceremony, the details of which will be posted on our website. The 2020 award recipients are:

**Teaching Science in College - Leo Schubert Award**

Sita Ramamurti, Ph.D., Trinity Washington University

Citation: *For years of dedication, passion, and creativity in teaching mathematics for college students.*

Sita Ramamurti is currently the Dean of the College of Arts and Sciences at Trinity Washington University in DC. In her 25 plus years of teaching collegiate mathematics, she has passionately engaged her students in active learning by integrating content-specific technology, designing and teaching quantitative literacy, reasoning, and interdisciplinary seminar courses. She also has a strong interest in reform and policy initiatives in K-12 education. As a research scholar her areas of focus are mathematical modeling and dynamical systems. Sita received both her B.Sc. and M.Sc. in Mathematics from India and earned her Ph.D. in Mathematics from George Washington University.

**Excellence in Research in Applied Mathematics**

Michael Donahue, Ph.D., National Institute of Standards and Technology

Citation: *For excellence in applied mathematics, leading to new tools for modeling and simulation which have transformed research into nanoscale magnetic films, structures and devices.*

Michael Donahue is leader of the Mathematical Software Group in the Information Technology Laboratory at the National Institute of Standards and Technology, and heads development of the OOMMF micromagnetics package. OOMMF, a critical piece of infrastructure for nanomagnetics research, is the most widely used micromagnetics simulation tool worldwide, sporting over 3000 citations. Before joining NIST in 1994, he was an industrial postdoctoral research associate at the University of Minnesota, working with Siemens Corporate Research on artificial neural networks and computer vision. Michael Donahue has authored over 50 journal publications, and holds Ph.D.s in mathematics and engineering from The Ohio State University.

**Excellence in Research in Computer Science**

Elham Tabassi, M.S., National Institute of Standards and Technology

Citation: *For outstanding contributions and leadership in computer vision, fingerprint image analysis, facial recognition algorithms, artificial intelligence, and machine learning.*

Elham Tabassi is the Chief of Staff in the Information Technology Laboratory at NIST and leads NIST AI program. As a scientist she has been working on various computer vision research projects with applications in biometrics evaluation and standards since 1999. She designed and developed NIST Fingerprint Image Quality (NFIQ) standard which is now an international standard for measuring fingerprint image quality and has been deployed in many large scale biometric applications worldwide. She received several awards, including the Women in Biometrics Award in 2016. Elham has a B.S.E.E. from Sharif University of Technology, and an M.S. from Santa Clara University.

**Excellence in Research in Physical Science**

John Villarrubia, Ph.D., National Institute of Standards and Technology

Citation: *For elucidating the physics of probe-sample interactions in scanning electron and atomic force microscopes for enabling accurate metrology of nanostructures to meet nanoelectronics manufacturing demands.*

John Villarrubia is a physicist and project leader in the Microsystems and Nanotechnology Division of the Physical Measurement Laboratory at the National Institute of Standards and Technology. Notable accomplishments include the use of mathematical morphology to invent a blind tip reconstruction method for scanning probe microscopy and applications of the physics of electron-solid interactions to dimensional measurements using secondary electron images. He is the recipient of three best paper awards, a Nanotech Briefs Nano50 Technology award, and Dept. of Commerce Gold and Silver medals. John has a B.S. in physics from Louisiana State University, an M.S. and a Ph.D. from Cornell University.

**Leadership in Biological Sciences**

Susan Gregurick, Ph.D., National Institutes of Health

Citation: *For extraordinary leadership in advancing computational methods in the biological sciences and leading the development and implementation of the first NIH Strategic Plan for Data Science*

Susan K. Gregurick is Associate Director for Data Science and Director of the Office of Data Science Strategy (ODSS) at the National Institutes of Health. Under her leadership, the ODSS leads the implementation of the NIH Strategic Plan for Data Science through scientific, technical, and operational collaboration with the institutes, centers, and offices that comprise NIH. Before beginning a career of government service, Susan was a professor of computational chemistry at the University of Maryland, Baltimore County. Susan Gregurick received her B.S. in chemistry and mathematics from the University of Michigan and her Ph.D. in physical chemistry from the University of Maryland.

**Leadership in Engineering**

Dawn Tilbury, Ph.D., National Science Foundation

Citation: *For leadership in advancing engineering research and for exceptional mentoring of engineering students*

Dawn M. Tilbury has been a professor of Mechanical Engineering at the University of Michigan since 1995. Her research interests lie broadly in the area of control systems, including applications to robotics and manufacturing systems. Since 2017, she has been the Assistant Director for Engineering at the National Science Foundation, where she oversees a federal budget of nearly $1 billion annually. She is a Fellow of both IEEE and ASME, and a Life Member of SWE. Dawn received the B.S. degree in Electrical Engineering, summa cum laude, from the University of Minnesota, and the M.S. and Ph.D. degrees in Electrical Engineering and Computer Sciences from the University of California, Berkeley.

**Leadership in Healthcare**

Anuradha Reddy, MD, Past President, Baltimore City Medical Society

Citation: *For leadership in healthcare and for serving the underprivileged community of Baltimore.*

Anuradha Reddy is a primary care physician and rheumatologist in Baltimore City, Maryland. She currently serves on MedChi's Board of Trustees and Legislative Council. Anuradha was the 107th President and seventh woman President of Baltimore City Medical Society, which was initially formed in 1805. Anuradha also served in other leadership positions, including as a president of the American Association of Physicians of Indian Origin, Maryland Chapter. Anuradha Reddy is a Fellow of the American College of Physicians. She did her residency in primary care in Muhlenberg Regional Medical Center, NJ and her Fellowship in Rheumatology from Cabrini Medical Center, NY.

**Leadership in IT Standards for Industry**

Lisa Carnahan, M.S., National Institute of Standards and Technology
Citation: *For national and international leadership in IT research and development for cybersecurity, privacy, health care testing infrastructure, standards, and conformance testing*

Lisa J. Carnahan is the Associate Director for IT Standardization in the Information Technology Laboratory at the National Institute of Standards and Technology. She is responsible for developing programmatic strategies for standards engagement, understanding potential standards opportunities in emerging technologies, and promoting the benefits of standards adoption in the federal government and industry. Lisa is the lead on conformity assessment aspects of the NIST Cybersecurity Framework and Privacy Framework and convenes the US Interagency International Cybersecurity Standardization Working Group. Lisa received a B.S. in Computer Applications and Information Systems from Clarion University, PA and received an M.S. in Computer Science from Johns Hopkins University, Maryland.

## Distinguished Career in Computer Science

Ming Lin, Ph.D., University of Maryland

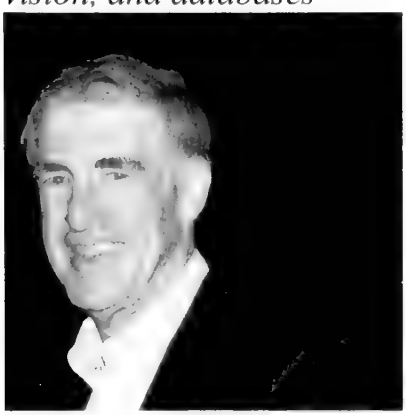
Citation: *For seminal contributions to computer graphics, virtual reality, robotics, and intelligent systems.*

Ming Lin is a Distinguished University Professor and holds the Elizabeth Stevinson Iribe Chair of Computer Science at the University of Maryland at College Park. She is also the John R. & Louise S. Parker Distinguished Professor Emerita at University of North Carolina at Chapel Hill. Ming has received several honors and awards, including an NSF Young Faculty Career Award, the UNC Hettleman Award for Scholarly Achievements, the Beverly W. Long Distinguished Term Professorship, the IEEE VGTC VR Technical Achievement Award and several best paper awards. She is a Fellow of ACM, IEEE, Eurographics, and SIGGRAPH Academy. Ming C. Lin received her B.S., M.S., Ph.D. in EECS from University of California, Berkeley.

**Distinguished Career in Computer Science**

Hanan Samet, Ph.D., University of Maryland

Citation: *For pioneering contributions to developing multidimensional spatial data structures and indexing for applications in graphics, GIS, vision, and databases*



Hanan Samet is a Distinguished University Professor of Computer Science at the University of Maryland. He wrote "Foundations of Multidimensional and Metric Data Structures," and the field's first two texts "The Design and Analysis of Spatial Data Structures" and "Applications of Spatial Data Structures: Computer Graphics, Image Processing and GIS". Hanan Samet is a Fellow of ACM, IEEE, IAPR, AAAS, UCGIS, and SIGGRAPH Academy, and received ACM's Paris Kanellakis Theory and Practice Award, IEEE Computer Society's Wallace McDowell Award, Founding chair of ACM SIGSPATIAL, Founding EIC ACM TSAS, and best paper awards in SIGMOD and SIGSPATIAL in 2008. Hanan Samet has a Ph.D. from Stanford University.

**Distinguished Career in Engineering**

Appajosula S. Rao, Ph.D., Nuclear Regulatory Commission

Citation: *For exceptional contributions to materials engineering research.*

Appajosula Srinivasa Rao is a Material Engineer and Program Manager at the US Nuclear Regulatory Commission (USNRC) in Washington, DC. Appajosula S. Rao's expertise is in Nuclear Materials, Physical Metallurgy, Corrosion, Finite Element and Neural Network Analysis. He has published nearly 250 papers in Journals, and Govt. Technical Reports and presented nearly 250 lectures all around the world. He received 4 patents and 35 awards and special citations. Appajosula S. Rao received M.Sc. Physical Chemistry, Ph.D. Applied Chemistry, from India, a second Ph.D. in Metallurgy and Materials Engineering, from England and M.S. in Engineering Management from George Washington University.

**Distinguished Career in Physical Science**

David Shifler, Ph.D., Office of Naval Research

Citation: *For distinguished and sustained contributions to corrosion science and for service to scientific communities*

David Shifler (Dave) has over 45 years' experience in the areas of materials and materials characterizations. He is a S&T program officer at the Office of Naval Research for high temperature propulsion materials and cellular materials. His responsibilities include recognizing emerging scientific and technological concepts and evaluate their feasibility and applicability to DoN missions. Dave is a Fellow of NACE International, the Institute of Corrosion in the UK, and ASM International, a registered professional engineer, and has received several awards. Dave received his BA in Chemistry from Western Maryland College, and his M.S.E. and Ph.D. from Johns Hopkins University in Materials Science and Engineering.

## Outgoing President: Judy Staveley

**Reflections of the Past Year as your outgoing President of the Washington Academy of Sciences**

Good evening members and awardees of the Washington Academy of Sciences.

As your outgoing president, I want to thank each one of you for the privilege of allowing me to represent you this past year as being the President of the Washington Academy of Sciences. As the President of the academy you get the opportunity to express your ideas and your passion for the academy. I have tried to be that voice this past year.

As I step down and pass the role over to Dr. Mina Izadjoo, I have no doubt she will be a wonderful loyal president to our members. Obviously we as presidents don't do all the work by ourselves, we need to thank our board members and loyal supporters who are behind the academy that keeps it going.

This past year has changed my life as I am sure it has changed yours.

## Incoming President, Mina Izadjoo

Good Evening Everyone,

It is a great pleasure to welcome you to the Washington Academy of Sciences' Annual Meeting and Award Ceremony via zoom.

I would like to thank you for joining us tonight and recognize this year's Award recipients for their contribution to science.

My appreciation and gratitude go to the Board Members who selflessly volunteered their time to serve the Academy and established new collaborations with other organizations.

The Academy brings together local scientists, encourages collaboration, and creates an enabling environment for the youth through its Junior Academy.

We need you, your passion for science and positive energy in helping us continue with our mission of promoting scientific interest not only for this generation but also for the next generation.

I do not want to take too much of your time but wanted to emphasize that you can work with us. Contact me or other Board Members at any time.

At this time, I would like to ask Dr. Ram Sriram to introduce himself and tonight's great speaker.

So, a very warm welcome to each one of you.

# Delegates to the Washington Academy of Sciences Representing Affiliated Scientific Societies

| | |
|---|---|
| Acoustical Society of America | Paul Arveson |
| American/International Association of Dental Research | J. Terrell Hoffeld |
| American Assoc. of Physics Teachers, Chesapeake Section | Frank R. Haig, S. J. |
| American Astronomical Society | Sethanne Howard |
| American Fisheries Society | Lee Benaka |
| American Institute of Aeronautics and Astronautics | David W. Brandt |
| American Institute of Mining, Metallurgy & Exploration | E. Lee Bray |
| American Meteorological Society | Vacant |
| American Nuclear Society | Charles Martin |
| American Phytopathological Society | Vacant |
| American Society for Cybernetics | Stuart Umpleby |
| American Society for Microbiology | Vacant |
| American Society of Civil Engineers | Vacant |
| American Society of Mechanical Engineers | Daniel J. Vavrick |
| American Society of Plant Physiology | Vacant |
| Anthropological Society of Washington | Vacant |
| ASM International | Toni Marechaux |
| Association for Women in Science | Jodi Wesemann |
| Association for Computing Machinery | Vacant |
| Association for Science, Technology, and Innovation | F. Douglas Witherspoon |
| Association of Information Technology Professionals | Vacant |
| Biological Society of Washington | Vacant |
| Botanical Society of Washington | Chris Puttock |
| Capital Area Food Protection Association | Keith Lempel |
| Chemical Society of Washington | Vacant |
| District of Columbia Institute of Chemists | Vacant |
| Eastern Sociological Society | Ronald W. Mandersheid |
| Electrochemical Society | Vacant |
| Entomological Society of Washington | Vacant |
| Geological Society of Washington | Jurate Landwehr |
| Historical Society of Washington DC | Vacant |
| Human Factors and Ergonomics Society | Gerald Krueger |

(continued on next page)

# Delegates to the Washington Academy of Sciences Representing Affiliated Scientific Societies

(continued from previous page)

| | |
|---|---|
| Institute of Electrical and Electronics Engineers, Washington Section | Richard Hill |
| Institute of Food Technologies, Washington DC Section | Taylor Wallace |
| Institute of Industrial Engineers, National Capital Chapter | Neal F. Schmeidler |
| International Association for Dental Research, American Section | Christopher Fox |
| International Society for the Systems Sciences | Vacant |
| International Society of Automation, Baltimore Washington Section | Richard Sommerfield |
| Instrument Society of America | Hank Hegner |
| Marine Technology Society | Jake Sobin |
| Maryland Native Plant Society | Vacant |
| Mathematical Association of America, Maryland-District of Columbia-Virginia Section | John Hamman |
| Medical Society of the District of Columbia | Julian Craig |
| National Capital Area Skeptics | Vacant |
| National Capital Astronomers | Jay H. Miller |
| National Geographic Society | Vacant |
| Optical Society of America, National Capital Section | Jim Heaney |
| Pest Science Society of America | Vacant |
| Philosophical Society of Washington | Larry S. Millstein |
| Society for Experimental Biology and Medicine | Vacant |
| Society of American Foresters, National Capital Society | Marilyn Buford |
| Society of American Military Engineers, Washington DC Post | Vacant |
| Society of Manufacturing Engineers, Washington DC Chapter | Vacant |
| Society of Mining, Metallurgy, and Exploration, Inc., Washington DC Section | E. Lee Bray |
| Soil and Water Conservation Society, National Capital Chapter | Erika Larsen |
| Technology Transfer Society, Washington Area Chapter | Richard Leshuk |
| Virginia Native Plant Society, Potowmack Chapter | Alan Ford |
| Washington DC Chapter of the Institute for Operations Research and the Management Sciences (WINFORMS) | Meagan Pitluck-Schmitt |
| Washington Evolutionary Systems Society | Vacant |
| Washington History of Science Club | Albert G. Gluckman |
| Washington Paint Technology Group | Vacant |
| Washington Society of Engineers | Alvin Reiner |
| Washington Society for the History of Medicine | Alain Touwaide |
| Washington Statistical Society | Michael P. Cohen |
| World Future Society, National Capital Region Chapter | Jim Honig |

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